AMERICAN

RAILROAD JOURNAL,

AND

MECHANICS' MAGAZINE.

No. 5, Vol. IV. New Series. | MARCH 1, 1840. | Whole No. 353. Vol. X.

In placing before our readers Mr. Ellet's plan for a suspension bridge for the Schuylkill, at Philadelphia, we beg to congratulate them upon the prospect of a re-introduction of this mode of bridge building. We have frequently commented upon the importance of this subject, and it may be remembered, that when introducing Mr. Ellet's pamphlet, on Wire Bridges, that we suggested the adoption of this form of structure for the Croton Acqueduct at Harlem river. Mr. Ellet, long since proposed a suspension bridge, but as no definite plan has yet been agreed upon, we think it not too late to take him up. We repeat what we then said, that a failure of the high bridge in even a small portion would cost more than a complete Wire Bridge which would answer in every particular. In these days of economy and retrenchment, it becomes our Water Commissioners to look well before they leap.

SUSPENSION BRIDGES.—PLAN OF THE WIRE SUSPENSION BRIDGE ABOUT TO BE CONSTRUCTED ACROSS THE SCHUYLKILL, AT PHILADELPHIA. *By Charles Ellet, Jr.*, Civil Engineer.

The wire suspension bridge represented in the annexed engraving, was designed in compliance with an invitation of the Commissioners of the city and county of Philadelphia; and is intended to succeed the Fairmount bridge, which was destroyed by fire in the summer of 1838. The plan was approved by the Board, who have since advertised for proposals for the erection of the work; and it is understood to be their intention to urge its immediate completion.

Without adverting to the merits of this plan, as a particular application of the principle of suspension; the fact that such a bridge is about to be constructed, cannot but be a matter of interest to the profession, as an auspice of the introduction into this country of an improvement which has deserved and acquired the most abundant success abroad.

Suspension bridges present many claims for public attention, which have been fully recognized wherever they have been fairly submitted to the test of experience. Nearly all the principal rivers of the cultivated portions of Europe flow through densely populated districts, in which the importance of an unembarrassed communication with the opposite shores, has been long appreciated; and bridges were consequently established at an early period, wherever the interest was sufficient to justify the expense of their erection. But nevertheless, as soon as one or two suspension bridges had been successfully accomplished, it was found that there were numerous places where similar works were greatly needed, and where the abilities of the inhabitants had yet proved to be unequal to the charge required for their erection and maintenance, by the application of any system of construction previously devised, which might thenceforth participate in the advantages held out by the new method. In the course of very few years, great numbers were accordingly erected; and it soon became manifest that the anticipated objections to the recent innovation were either entirely fanciful, or such as could be readily removed.

Popular opinion had foreseen inconvenience from the supposed instability of the platform; but experience taught, that when properly built, the motion in an arch of 300 feet opening, or more, did not exceed that which has place in ordinary wooden bridges; and theory at the same time demonstrated that the oscillations produced by an equal disturbing force diminish as the length of the span is augmented.

The apprehension of a rupture of the cables, was dissipated before the proofs which were furnished by science and experiment;—proofs which show that of all the applications of building materials to architectural purposes, none admitted of greater certainty than that of iron, and especially of iron wire, to the support of bridges; that the tension to which the metal was exposed, is susceptible of the most rigorous determination, and its strength, of the most accurate preparatory trials.

At the same time that these positive objections were relieved, the comparative value of the system was made equally apparent. The unrivalled beauty, and even gracefulness, of those examples which had been constructed, gave them a preference for positions where ornament was essential and elegance a merit. Their susceptibility of being applied to rivers where the width of span must necessarily be very great, rendered them peculiarly appropriate for situations in which it was requisite, for the preservation of the navigation, or other object, to avoid obstructing the water way by the establishment of too many piers in the channel.* They possessed, withall, the merit of durability, to an extent which will render them monumental; and to these advantages was superadded a claim not unfre-

* The span of the Freibourg bridge, built by M. Chaley, is 889 English feet, and its flooring is 167 feet above the surface of the Sarine. Another bridge in Switzerland, by the same officer, over the valley of Gottron, has a span of 152 metres (499 feet,) and is elevated 340 feet above the bottom of the valley. Ships pass under the flooring of the Menai bridge under full sail.

quently esteemed as still more important: viz. that the first outlay necessary for their construction, will generally be less than that for any other description of bridges. There are exceptions to this assertion, but where they obtain, the stream must be very inconsiderable, and such as will permit the adoption of the wooden bridge requiring the simplest possible combination of the materials.

With these claims—which in fact cover the whole ground on which a preference could be founded—the system of suspension prevailed throughout Europe; and was immediately applied to the most important streams, in the heart of populous cities, and on various lines of railroads. Arches were commenced and successfully accomplished, from two to three times as wide as had ever before been attempted; and the practice of constructing bridges of any other description, was nearly superseded by the favor yielded to a system which appeared to combine every possible advantage, with a susceptibility for universal application, and which could scarcely be opposed by one solid objection.

The rivers of the United States, and especially those west of the Alleghany, present a broad field for the introduction and development of this improvement. In general, these streams are remarkably wide, and subject to freshets of great height and power; they are navigable for steam boats during a certain portion of the year, and sustain a commerce of the highest value to the country; considerations which may be regarded as so many objections to the obstructing of their channels by piers, independently of the expense which the erection of such works, in these circumstances necessarily involves. Besides, the sparseness of the population in most of the States, and the deficiency of funds incident to that condition of things, renders it important to fix on plans which will at the same time require the smallest annual charge for maintenance, and the smallest capital for original construction.

These conditions are best satisfied by the pendant principle; and its introduction into this country must therefore be regarded as a valuable contribution to the means of perfecting our great and numerous lines of intercommunication.

The engraving of the bridge intended to be constructed across the Schuylkill offers a very faint idea of the appearance presented by such a structure, when tastefully designed and viewed in place. It will, however, serve to convey an impression of the general appearance of suspension bridges, to those who have not possessed the opportunity of witnessing some of the fine specimens of the art which have of late years been erected in Europe.

This bridge consists of one principal opening 400 feet wide, and two lateral stone arches of 65 feet. Upon the piers which sustain the thrust of these lateral arches are to be erected 4 isolated columns for the support of the wire cables which uphold the platform. There are four of these cables, each of which is about 600 feet in length, from 4 to 5 inches in diameter, and composed of about 900 strands of iron wire. The wire is the $\frac{1}{100}$ of

a foot in diameter; and each strand is covered with a coat of durable varnish before it is put in the cable.

The cables pass over the summits of the granite columns, where they bear on a moveable saddle, resting on rollers of cast iron, which are placed between the saddle and the upper surface of the capital. These rollers have a slight play, and the object of introducing them is to prevent the columns from being disturbed by movements of the cables, whether caused by the dilatation of the wire consequent on atmospherical changes of temperature, or the small oscillations and vibratory movements of the platform.

The ends of the cables descend through appertures in the masonry, and are securely anchored in the abutments of the littoral arches; passages are formed for the easy access of the superintendant to these fastenings, in order to admit, if necessary, of the removal of a cable, or the application of fresh paint or varnish to the iron as often as it may be judged expedient.

The width of the flooring of the bridge is 26 feet; of which space 18 feet in the centre, is intended for a carriage way, and 4 feet on each side, next to the parapets, for foot ways. The foot ways are raised 10 inches above the level of the carriage way.

The dimensions of the cables are assigned with a view to the support of the bridge when the whole area of the platform is occupied by people; and it is assumed, in the calculation, that the number who can conveniently stand upon it is equal to 3500 men of ordinary stature. The weight of this number of people, estimated at 150 pounds per man, is 234 tons. The weight of the bridge, or of that portion of it which is suspended between the columns, is computed at 214 tons; and consequently the whole weight on the cables, where the platform supports a load of this amount, will be 448 tons; from which will result a tension at the points of support—the summits of the columns—of 720 tons. The ultimate tenacity of the wire which will be used, may be safely estimated at three fifths of a ton for each strand; so that the aggregate strength of all the wires in the four cables—which contain 3600 strand—will be 2160 tons; or three times the tension to which they will be exposed when the flooring is occupied by 3500 men.

The bridge is to be sustained by 4 granite columns standing on bases 9 feet square; which are obviously too light to be depended on for the support of any material part of the tension; and it is consequently essential that the direction of the cables, on the opposite sides of the columns should be such, that the resultant may fall as nearly as possible in the centre of their bases. By this arrangement the horizontal components of the tension neutralize each other, and each column is subjected only to a pressure in the direction of its axis, of about 225 tons, or half the weight of the bridge and its load. The stability of the columns is consequently greatly increased by the weight which they sustain; and it would be much more difficult to overthrow them when crossed by the cables and receiving the pressure due to the load which they support, than when isolated.

The platform is one foot higher in the centre than at the abutments; and

it is guarded on the sides by parapets, which fulfil the double office of protecting the passengers and reducing the oscillations to which the structure is liable.

The preceeding remarks apply to the plan of the bridge as it was presented and approved; but since its adoption by the commissioners a change of the location has caused certain modifications to be made to adapt it to the new site.

For the American Railroad Journal and Mechanics' Magazine.

INTERNAL IMPROVEMENTS OF NEW YORK. NO. 4.

We have shown in the preceeding numbers that, by lengthening the locks of the Erie canal, and constructing duplicate ones at certain points, its capacity for the transportation of freight will be doubled, and by an improvement in its channel, in raising the surface 1 to 1½ feet, and adding to the width 16 feet, its capacity will be fully quadruple what it now is, and such proportions obtained in respect to the size of the boats and the canal, as will render the cost of transportation with animal power a minimum.

All this may be accomplished at an expense not exceeding six millions of dollars, or about the one seventh part of the cost of the enlargement on the plan contemplated. The State will save by this plan nearly $30,000,000—the canal will be abundantly large enough to accommodate any prospective increase in the trade upon it for years to come, and the great desideratum of cheap transportation, effected to a degree as perfect, when all the attendant circumstances are considered, as can be attained by the proposed enlargement.

Although the arguments advanced, are believed to be quite sufficient to justify the conclusions to which we have arrived, we will give some further reasons in confirmation of their correctness.

Supposing the Erie canal to be enlarged the whole distance from Albany to Buffalo, it is easy to perceive that a similar improvement of the Oswego canal will speedily follow. The limited extent of the Oswego canal only 38 miles, half of which is natural navigation, and being, as it is, the channel of communication with lake Ontario, its importance is such as leaves no reason to doubt that its enlargement will follow that of the Erie canal, as certainly as its construction followed that of the Erie canal in the first instance.

The Cayuga and Seneca canal connecting with the Cayuga and Seneca lakes, and communicating with a fertile and populous portion of the State will also present claims for an enlargement which will be irresistable, and hence we may reasonably expect that if the plan of the enlargement is persevered in, the State in order to perfect the system will be forced into the expenditure of some seven or eight millions more than has been estimated. The advocates of the Erie Canal enlargement, although they must have seen the necessity of adding also to the size of these canals, have been silent on the subject. They have advocated the enlargement on the ground

that the large boats would be better adapted to the navigation of the Hudson river and the lakes mentioned in the interior of the State, but have been silent as to the whole expense necessary to be incurred in carrying this plan into effect.

As to the other canals to which the *enlightened* internal improvement policy of the State has given birth, viz. the Chemung, Crooked Lake, Chenango, and the two less hopeful ones yet in embryo, the Black river and the Genessee valley, there is no danger of their acquiring an importance sufficient to render their enlargement in the least degree probable. These canals, however, in connection with the two first named, until such time as they shall be enlarged, must labor under the very serious inconvenience of a transhipment of freight to and from the boats of the Erie canal at the several points of junction, owing to the different dimensions of the boats and character of the navigation upon each.

The delay, expense and embarrassment of this transhipment has not been fully realised.

It has been shown from published reports, that of the 640,000 tons which came to tide water on the Erie canal in the year 1838, two-thirds was lumber or the product of the forest. It is well known that most of this is brought to the Erie canal from the lateral canals and is transported the most of it in boats. Flour, also, and other articles, are furnished in large quantities from the lateral canals, particularly the Oswego and Cayuga and Seneca.

The expense of transhipment must of course depend very much upon the nature of the lading, and will embrace the following items.

1. The interest on the cost, and depreciation of the boats during the time occupied in making the transfer.
2. Wages of boat hands for the same time.
3. Interest upon the cost, depreciation and feed of horses.
4. Dock rents and fixtures, and occasional warehousing expenses.
5. Such additional hands as may be necessary.

By giving to these several items their proper value, it will be found, we believe, that the average cost of transhipment, independent of the embarrassment consequent upon the delay, and the injury upon the articles transhiped, will be not much less than fifty cents per ton, or equal to the present average *cost* of transportation of down freight, independent of tolls on *fifty* miles of the canal.

Supposing, therefore, as is asserted, that the saving in the cost of transportation on the enlarged canal will be 50 per cent of the present rates, freight from the branch canals must be carried 100 miles on the Erie canal to make the expense what it now is. Putting the saving at 25 per cent instead of 50, which is undoubtedly nearer the truth, and the distance at which the expense will be the same as at present, is 200 miles. That is, if the distance at which freight from the lateral canals is carried in the Erie canal, is less than 200 miles, the total cost of transportation will be *greater*

than it now is. This certainly does not show any *very great advantage* to be derived by the sections of country in the vicinity of the branch canals from the enlargement, unless the circumstance of paying as *high* or *higher* than they now do for transportation, and bearing, at the same time, their portion of the burden of the debt to be contracted, can be esteemed an advantage.

Again, those who are conversant with the mode in which the transportation is conducted on the Erie canal, are aware that the business is almost wholly in the hands of companies acting in concert and wielding an immense capital, and hence are able to defy all ordinary competition, monopolising the business, and becoming carriers at their own prices.

The power and extent of this combination, although its influence was then but partially developed, were manifested when in 1833 the Canal Board reduced the tolls to near the constitutional limit, with a view of bringing in the trade of the country west of Buffalo. Instead of producing the effect anticipated, the forwarding companies immediately raised their charges, thus converting a measure of great public benefit into a source of private emolument.

If the Erie canal is improved so as to admit of any material reduction in the cost of transportation, what guarantee have the public that the same scenes will not be re-enacted, and that instead of deriving any benefit themselves from so great an expenditure they are not putting money into the coffers of a monopoly which has already rendered itself odious by its unreasonable exactions? Certain it is, that however great is the evil of this monopoly at the present time, it will be much augmented should the project of the enlargement be accomplished. This follows from the fact of the business being conducted on a larger scale, the boats being larger and more expensive to build and to navigate will prevent many from engaging in the business of transportation, and drive therefrom also many who are now engaged, but whose capital and means although adequate to prevent exigencies are too limited for the purchase and navigation of boats upon the large canal.

There are still other reasons why the cost of transportation will not probably be reduced to the degree anticipated. The line of railway alluded to in a previous number, extending from Albany to Buffalo, will soon be completed. The restrictions imposed by the State upon the railway, as it regards the conveyance of freight, opposed, as it is, to the enlightened principles of political economy, and the true interests of the people of the State, will ere long be removed, and when so removed, the railway will carry a very large proportion of the merchandize, which now pays, for both tolls and transportation, more than double the charges upon other descriptions of freight. This change will not only make considerable inroads upon the tolls from the canal, but the forwarders loosing, as they will, their very great profits on merchandize will be compelled to charge higher on other freight. This, although it may not cause any in-

crease in charges over *present* prices, will prevent their being reduced as low as they otherwise would be.

That the railway will carry merchandize to a very considerable extent, when the restrictions alluded to are removed, is obvious from the experience on the lakes, where the steamboats take most of the freight of this description at much higher rates than sail vessels, principally on account of the saving in time by that mode of conveyance.

Rapidity and certainty of conveyance are very important to the merchant located in the distant interior. It gives him a more speedy return on capital invested, and with the convenience which a winter conveyance upon a railway will afford, he will not be obliged to purchase so largely when procuring his fall supplies, and thus derive a double advantage in the constant receipt of fresh supplies, according as his necessities may require, and in the less amount of capital needful for the transaction of his business.

That the transportation of merchandize upon the railway will take place, to a very great extent is obvious for another reason. If but a single merchant in a village or city in the interior should obtain his supplies by the more speedy conveyance of the railway, others will be compelled to do the same, and that such will be the natural course which business will take, appears to us to be too obvious to need further comment.

As to the effect of a reduction in the charges of transportation upon the canal in drawing to it a greater amount of business by pushing further to the south and west the dividing line which separates the portions of the valley of the St. Lawrence and upper Mississippi doing business respectively with New York and the cities south, we cannot but believe the anticipations of the friends of the enlargement have been too sanguine. The tide of emigration to the States and Territories west, is yet strong and will undoubtedly so continue for many years to come, the consequence of which is a consumption within their own borders, of their surplus products, leaving comparatively little for the Atlantic marts.

That the influence of a reduction of tolls in inviting business to the canal from the sections of country mentioned, must for some time be limited, appears probable from the fact that the business of the canal thus far has been mainly from within the limits of N. York, notwithstanding in the last six or seven years there has been a general reduction of 25 per ct. upon the tolls and a further reduction of full 30 per ct., arrising out of the extraordinary advance in prices, which for the last five years has taken place under the *benign* influence of the *credit* system. The country having began to realize the bitter fruits of making that which is a mere *evidence of debt* a *standard of value*, or in other words, of giving to paper which possesses no intrinsic value, the properties of coin, there is every reason to believe that prices will recede until they shall reach a point at which they can be permanently maintained. The tolls of the canal being based not upon the value but upon the weight or dimensions of the several commodities, this *reduction* in prices is practically equivalent to an *increase* in tolls.

The business of the canal must, to a considerable extent, experience the injurious effect of this change in prices, or relative increase in tolls, the remedy, supposing it expedient to apply any, which is doubtful, being beyond the reach of the State authorities, since the tolls are now down to the limit fixed by the constitution.

There is another view of the subject of the probable effect of the enlargement in reducing the charges for transportation which merits the most serious attention.

In the report of the comptroller for the year 1838, from which we quote, not having the last report at hand to refer to, the nett revenue of the the State canals is thus given.

Surplus of the revenues of the canals from tolls over and above the cost of their maintenance,	$841,888,09
If the *interest* paid for the year on the debt of the lateral canals *which are finished*, be deducted,	170,000,00
It leaves a surplus of	$671,888,09

The revenue from the Erie and Champlain canals, being the only canals which more than pay expenses, has not varied much for the last seven years. During the whole of this time it has ranged between $1,300,000 and $1,400,000. This being the fact, there is no good reason to believe that the increase will be very rapid for several years to come. If it remains the same, the only available means of the State, derived from the canals, for paying off the debt of the enlargement, is the surplus above stated of $671,888,09. This it must be remarked, is the surplus after paying *interest*, without *reducing* the principal of the debt of the lateral canals *which are finished*. It does not therefore include the two last of the *pauper* progeny of the State, viz., the Black River and the Genessee Valley. The interest on these being deducted, amounting to $600,000, it being doubtful whether they will ever pay the cost of maintenance, and there remains but a precious small sum for defraying the interest on the cost of the enlargement, amounting, at 6 per cent., to $2,400,000 per annum.

That the revenue of the Erie canal will continue to increase, we firmly believe—but the expenses also will increase; and it should be borne in mind that the most liberal estimate of the revenue for many years, will not be sufficient to keep down the interest, if the plan of the enlargement is persevered in, and a resort to taxation will become necessary to preserve the faith of the State, and obtain means for defraying the current expenses of the government.

If the enlargement of the Erie canal is accomplished on the scale proposed its probable cost for reasons given in our first number will amount to	$40,000,000
Debt of the lateral canals in operation, about	2,500,000
Cost of the Genessee Valley canal,	6,000,000
" Black river "	4,000,000

Expense to be incurred in enlarging the Cayuga and Seneca and Oswego canals, say	7,000,000
" rebuilding locks on Chemung canal of stone, they being now of wood and almost useless,	700,000
" rebuilding also the locks on Chenango canal which are of stone and wood,	1,300,000
	$61,500,000

The State of New York, without entering into any *new* projects, is already in for about $60,000,000 *on account of her canals alone* without even a reasonable prospect of being able without resort to taxation, to pay the interest on that amount. Is it not time to pause in this career of extravagance. *Of all the visionary projects into which the State has been drawn by the influence of unwise counsels, the enlargement of the Erie canal is the most visionary, and the sooner she makes haste to retrace her steps the better.*

FULTON.

For the American Railroad Journal and Mechanics' Magazine.

ATMOSPHERIC RESISTANCE TO LOCOMOTION ON RAILROADS--DR. LARDNER'S EXPERIMENTS, ETC. BY WM. M'CLELLAND CUSHMAN, CIVIL ENGINEER.

I avail myself of a favorable occasion to notice some alledged discoveries in respect to the quantity of resistance the atmosphere makes to the progress of a train of cars when tracked by locomotive engines. The strictures upon this subject published in the third number of your Journal, abundantly evince the character of Dr. Lardner's claims, and his total failure to *establish any thing*, either original or secondary. I, however feel myself called upon to give some further attention to the subject, in my own behalf, inasmuch as I had long since investigated its effects, and published a formula expressing them, in July last year, as part of a "new expression of the powers, velocity, etc., of locomotive engines." I intend, however, while noticing Dr. Lardner's pretensions, to restrict myself chiefly to the more full development of the *rationale* of atmospheric resistance, than I then had occasion to do—a *practical indication of its value* being all I, at that time, aimed to effect. It may be remarked that the views in question first enlightened our horizon the present month, and were published in England in October last. This statement would be abundantly sufficient in point of priority, even assuming them to be *true* or *tenable;* but I may here be allowed to repeat that (as stated in my paper of July) my expression was investigated, *in extenso*, "on perusal of Chev. de Pambour's work"—which was in the fall of the year of its publication. So that the effect of the atmosphere upon locomotion on railroads, had been established with precision in this country, some three years since and more; and published some eight months before we were informed (and it may be very true indeed) that "no

details exist, nor have any experiments ever been made, by which the resistance (to wit, such as Dr. Lardner has discovered) of the air to a train of railway carriages could be obtained by any calculation whatever; nor was the amount of *such* resistance ever suspected, even by the persons who have ventured to utter such statements, as have (has?) *here* (to wit, by himself) *been proved to exist.*" I for one (and most engineers will join me) must confess that I never did entertain a suspicion of *such* resistance, etc., as is set forth in this famous course of experiments.

I may perhaps be indulged in a reflection. It is not an unusual occurrence for unprofessional men to fall into egregious errors, when they pass from the popular and merely descriptive knowledge of a subject, to the development and application of complicate laws and principles to practical purposes—which is properly the province of the engineer. This I take to be the case in the present instance. As a popular lecturer upon the steam engine, Dr. L. has justly a high repute—that his fame rests here alone has been illustrated in more than one instance. Let his admirers recur to his extremely absurd estimates of the capabilities of the superb steam palaces now flying between the shores of the ancient and modern hemispheres—secure and uniform, maugre all presages—as if plying between the banks which sustain two opposite marts on the Hudson.

In illustrating the *rationale* of atmospheric action upon a train of railway carriages, it will be best, in the first instance, to pre-establish, by specific statements, an idea of the proportion of motive power actually annulled by such action, when performing *regularly the duty required in practice*—other trials, upon trains allowed to generate their own speed, can in few, if any instances, be of service in researches made with the view of determining the *actual amount of resistance*, though they may serve for illustrating a point; and such consequently do not present the data required in forming conclusive opinions. This distinction will be carefully observed; for erratic opinions upon this subject, are very generally, if not exclusively, to be referred to indiscriminate reliance upon this class of trials *as practical results.* (*Note.*)

I have shown (R. R. Journal, vol. 9, No. 2.) that, upon several lines of railroad of the same width of track, even with engines of very dissimilar constructions, the atmospheric resistance to the progress of the engine and train, was, *in general*, very nearly expressed by the formula $\cdot 4\ v^2$, the velocity of the motion being v miles per hour. At 30 miles per hour (a velocity exceeding the average rate of motion upon any railroad extant) the resistance is then 360 lbs. Now, the maximum effective power or force of steam, of the most puissant engines of the Liverpool railroad, is 2112 lbs. when working with their usual pressure in the boiler—to wit, 70 lbs. The proportion of power annulled then, will not exceed $\frac{1}{6}$ of the maximum effective pressure of steam exerted, when the velocity is *greater than the actual rate of running* upon any railway in this or the other hemisphere.

At 20 miles per hour, its value is 160 lbs. or $\frac{1}{13}$ the effective force of steam, as this is about equal to the friction of the engine, unloaded, it will furnish a very good notion of the amount of opposition experienced, as well as of its relative consequence as part of the total tractive force the engine is capable of exerting. This velocity is the *actual rate of the passenger trains* upon the Liverpool, and upon some of the best roads in this country. *Freight trains* usually travel at more moderate rates—the average rate being 12·5 miles per hour. The resistance for these is then 62 lbs. or $\frac{1}{34}$ part of the effective force the engine is capable of exerting. It is certain therefore, that, allowing the obstruction to be considerable, and always large enough to form a *necessary element* in reckoning the total resisting forces to be encountered, those other elements of the total resisting force must still always greatly predominate over that of the air—in the practical operation of rail-roads.

For further illustration in this respect, the following table is submitted, it is computed according to formula previously exhibited, viz: $\cdot 4\, v^2$.

Velocity of the Engine in miles per hour.		Actual resistance of the air upon the train at those velocities in lbs. avoirdupoise.		Proportion the loss of effect bears to the maximum power of the engine.	
	5.		10.		1 in 211.2
	10.		40.		1 " 52.8
	15.		90.		1 " 23.5
	20.		160.		1 " 13.2
	25.		250.		1 " 8.45
	30.		360.		1 " 8.87
	35.		490.		1 " 4.31

The amount of atmospheric resistance *does not depend*, in any sensible degree, upon the *length* or *volume* of the train.

The Atlas, the engine instanced above, with a train of 40 cars, does not show any greater proportionate resistance, at the same speed, than with a train of but 12 cars. In the first instance its train was about 475. feet long, in the second only 160. feet or but one-third the volume of the former. The same conclusion follows from each approved result of that course of experiments; wherein it has already been stated, the quantity of resistance is generally expressed by the formula of $\cdot 4v^2$; that is, to use ordinary language, *the resistance is always constant with the same velocity.* I have found very precisely the same result upon other roads wherever an opportunity has offered to test it by well conducted experiment, even with trains of much greater length than the longest of those specified. Dr. Lardner, therefore, asserts the precise *contrary* of the results of extended *experience upon engines, while doing their usual requirements*, when he says that the *resistance from the air is measured only by the volume* of the train. Experience drawn from the *objects themselves* being repugnant to this opinion, I beg leave to inquire if it has any *indirect support from analogy.* Now nothing has been more fully settled by a series of excellent experiments, than this. Take a body constituted of two cones placed base to base (the height of each = diam. of base,) and impel it through a fluid in the direction of its axis, and a certain force will be required: but on interpolating a short cylinder between the cones, the force required to move the lengthened body with the same velocity, will not be nearly so great—if the fluid be water,

for instance, the *reduction of resistance will be in the ratio* 380 *to* 1000. Again, a blunt cylinder, impelled with any velocity, through the air, requires less force than a cone or hemisphere with the flat side presented—*the reduction* being expressed in the relation of the Nos. 288 to 291 and 288. Passing to instances upon a practical scale, observation instructs us that upon canals, boats of length require *less force* to track them, than short boats of equal transverse section: another instance in point is that the speed of steamers has, in many instances, been increased without changing their machinery—simply by sawing and interpolating a-midships—that is, the resistance has been *reduced by the addition in length*. Could the precise section of frontage of a train be obtained with certainty, by direct means, there is no reason to doubt but that a rigid plane surface of equal extent, tracked by an engine, would require much *more force to impel*, at equal speed, *than the train* of which it is the section, would. The rationale of this is perfectly understood—with the cylinder, long hulks, &c., the fluid *does* more readily and perfectly follow and replace the vacuity left behind them as they advance, than with the other objects of equal section—and although a certain increase of resistance in the article of friction, does attend increment of length, it has evidently little significance in comparison with the force required to overcome the mere *unbalanced pressure of fluid always superadded to its resistance proper*, in proportion as the figure favors the formation of a void in rear of the object. Analogies strictly in point, *do not*, then, *give any support to such views* as have been advanced by Dr. Lardner; but quite the reverse, they bid us rather to apprehend that the quantity of atmospheric resistance is at least *as great*, when an engine and tender move off *without any useful load*, as when it has a train in convoy.

The general expression of the resistance which has been established may be translated into language in these terms, viz.

The resistance of the air upon trains tracked by locomotive engines is as if made upon an *invariable section of frontage*, and *varies in amount* only with the velocity of motion—upon any given line of road. These results, which have been deduced from regular performances, are besides perfectly agreeable to analogy; and it is also evident that none other than these are consistent with the established laws of pneumatics. But that *no part* even of the resistance (in the way of increase at least) has any dependence upon the volume of the train, may be more clearly perceived on evolving the resisting section *implied by the formula* and bringing it into contrast *with measures taken upon the engines themselves*. For this purpose, put S for the unknown section of frontage implied by the formula, agreeably to the principle of pneumatics, and p for the resistance of a square foot of surface, at any observed velocity represented by v' miles per hour. We have then for the total resistance of the air upon a train $pS\frac{v^2}{v'^2}$ lbs., or more exactly still, by the law of Borda, $p\left(S^{\frac{1}{2}}\right)^{2.2}\frac{v^2}{v'^2}$ lbs. at any time when the engine

is running with a speed of v miles per hour. Now if *the frontage alone determines the resistance*, this last expression will be equal to $\cdot 4v^2$ the value deduced from the observed performance of engines—that is, we will have $p\left(S^{\frac{1}{2}}\right)^{2\cdot 2}\frac{v^2}{v'^2}=\cdot 4v^2$ and ultimately $S=\left(\frac{\cdot 4v^2}{p}\right)^{1\cdot 1}$ for the area of front age which *must have been present*, according to established principles in the series of performances. And this deduced area and that made up from measures upon the engines, cannot be allowed to differ sensibly from each other, on our hypothesis. Now at 20 miles per hour the force upon a square foot of surface is 1.968 lbs., and consequently $S=\left(\cdot 4\frac{400}{1.968}\right)^{1\cdot 1}=54{\cdot}6$ ft expresses accurately the *aggregate frontage presented by every member of the train* reduced to *plane* surface. Again, it is certain that, looking to facts, there is an unbroken frontage (measuring usually about $6\times 9=54$ sq. ft.) included between the sides of the tender or cars one way, and between the roofing of the tender and base of the furnace, the other, superadding for extra effect upon the small members, the area by direct measures, proves to be nearly, if not exactly, identical with our first result as evolved from the formula $\cdot 4v^2$. Now if this formula depended in any sensible degree upon the volume of the train, the near approach of the two results, would have been impossible. On the contrary, in that case, there must have been an *excess against the direct measures*—which excess, if the newfangled views had any basis to support them, must have been *indefinitely great*. The facts, as seen, are diametrically the reverse—for the excess is decidedly *in favor* of the direct measures, but so slightly as to give assurance that it can never, after accounting in the result all minutia, be made to exceed the other by an hundredth part of the total section.

It is plain then, that in practice the resistance, if any thing, is rather less than the actual frontage would give; but also that the difference is inappreciable. We are authorised, therefore, to assert that the atmospheric resistance is not only *as if made upon an invariable section of frontage*, but that it *depends, exclusively, upon that section, for its amount*. Dr. Lardner's opinions have consequently no foundation in fact and he is welcome to all the credit of their discovery.

Albany, February, 1840.

NOTE.—The resistance of the air can only be truly deduced from trials similar to the usual performances of engines—there must be *uniform* velocity, etc. And it cannot be obtained during such trials if any other element limiting the speed or power, remains undetermined. This was the case until the law of vaporization, as dependent upon velocity, had been established. Having done this, the amount of atmospheric resistance was deduced as represented in the paper containing my new expression of the powers, velocities, etc. De Pambour in his work made no attempt to determine either of these elements, however

his measures of the friction of engines and of carriages exclude the atmospheric influence entirely—most of his trials with engines being made without velocity, and the others at so slow a rate of motion, that its influence was insensible. By excluding the leading car, he also freed the friction of carriages from its influence. The value of this last, with the cars there used, is accurately 8 lbs. per ton, or $\frac{1}{280}$ of the gross weight. Having instituted frequent comparisons of computed, with the running rates, upon several roads, I find no reason to disparage that result, in any degree, at least with similar cars. Let it however be observed that light cars have less friction per ton than laden cars. The rationale of this is in the compound nature of friction—in the former the resistance is made chiefly at the periphery, where the wheel bears upon the rail—in the other, at the axle—this last, in cars of the usual dimensions, greatly predominating. This may be mentioned among the anomalies of de Pambour's course.

SAMUEL ADAMS' COMBINED RIFLE AND SHOT GUN.

We have had presented to our notice the above named ingeniously contrived improvement in fire arms. It possesses the grand requisite of all useful improvements in such things—perfect simplicity.

The piece when used as a rifle, resembles ordinary arms of that description, and may be loaded as usual, or at the breech by a metallic cartridge. A small piece is unscrewed at the muzzle which loosens the inner or rifle barrel. This is kept in its place by means of an enlargement at the breech in that portion of the barrel in which the metallic cartridge is fitted. The space thus left when the inner barrel is removed, leaves room for a larger metallic cartridge for the shot gun, which may likewise be loaded in both ways.

The rifle sight turns on a pivot, and may be put out of the way when the smooth bore is used. The perfect adaptation of all the parts, renders the united barrels quite as firm as if in one entire piece—and as a rifle it is not heavier—or as a shot gun, lighter than common arms of those kinds.

We consider it as completely supplying the place of two distinct pieces, and combining economy of space and and money. For travellers such a gun would prove invaluable—while the hunter is thus enabled to command game of all descriptions by a single gun. The change may be made in half a minute, from a rifle to a fowling piece.

We understand that a small portion of the right is offered for sale, and we conceive it to be a fine investment—being free from the common objection to improvements in fire arms—complication of parts.

We are indebted to Mr. Roebling for a communication on the "Theory of the Crank," which came however, too late for this number. It will appear in the next number.

BENEFITS OF RAILROADS.—We copy the following statement of the performance of a locomotive steam engine on a Pennsylvania railroad. Facts like these are convincing proofs of the superiority of railroads over

canals. To this statement we annex some remarks from the Journal of Commerce, elicited by certain articles which have recently appeared in the Railroad Journal on the enlargement of the Erie canal. We profess not to be fully acquainted with this subject, but if the large sum of money necessary to complete this enlargement can be turned to the construction of railroads, we are of opinion a much greater good will be accomplished.

Ed. N. Y. Times.

UNEXAMPLED PERFORMANCE IN THIS COUNTRY OR EUROPE.—The engine "Gowan & Marx," built by Messrs. Eastwick & Harrison, for the Philadelphia and Reading railroad company, weighing eleven tons, drew yesterday, over the railway from Reading to the Columbia railroad bridge, Peters' Island, one hundred and one loaded cars.

Gross weight of train, 423 tons of 2240 lbs.
Nett " " 268½ " "

Running time, 5 hours 23 minutes—distance 54½ miles, being at an average speed of about 10 miles per hour.

The coal consumed by the engine in drawing this load was 5600 lbs. or rather less than two and a half tons.

The quantity of oil consumed by the whole train of cars was 5½ quarts, being about half a gill for each car.

The freight was as follows:

2002 barrels of flour, weighing	190½ tons
459 kegs of nails,	22 "
52 barrels of whiskey,	11¾ "
20 hogsheads of corn meal,	13¾ "
5 " whiskey,	3¼ "
7 " linseed oil,	7½ "
Lot of band iron, etc.,	19¾ "
Total nett freight,	268½ "

Philadelphia Gazette.

The following is a statement of the *receipt* and *expense* of transporting 423 tons of 2240 lbs., over the Philadelphia and Reading railway. The nett load of 2000 lbs. to the ton was 307 tons or 101 cars.

The freight received by bills of parcels was $835 19 for the down trip—or $2 78 per ton of 2000 lbs. carried 54½ miles in five hours and twenty-three minutes.

The *daily* expense of running the locomotive to carry a train one trip, is stated at	$16 67
To this add wear and tear of 101 cars, at the very liberal allowance of 30 cents each per diem, (this rate will renew them every three years,)	30 30
Add four hands at the brakes,	4
Five and a half quarts of oil,	2
	$52 97

The above does not include the incidental expenses of warehouse and unloading. On the supposition that the cars return empty, it will cost $105 94—it will cost at this rate 35 cents to transport one ton of coal, in a train of cars with 300 tons, 54½ miles, between 6 and 7 mills per ton per mile.

The company calculate to pass daily 2250 tons of coal in fifteen trains with half the above load. This will give them a gross income at $2 per ton on only 708,770 tons, per 315 days, of $1,417,540.

The facilities of this road, from its favorable grades, to transport coal, far exceeds the Schuylkill canal along side of which it is located.

The capacity of the canal is limited to the number of lockages, during the season of transportation. This period will not usually, on an average, (excluding Sundays, left out on the railroad estimate,) exceed 200 days. If a lockage is allowed every ten minutes, day and night, for the whole season, with the supposition that each boat carries to tide water, on an average, from the mines, 30 tons of coal, we have 744,000 tons, the capacity of the canals.

As regards the railway, a train with 200 tons could pass every half hour, say for 315 days, equal to 2,994,000 tons. On a well regulated railway, there would be no difficulty in starting a train every 15 minutes—a railroad with a double track, is nearly equal to travelling in a circle.

A POPULAR EXPOSITION OF THE INCORRECTNESS OF THE TARIFFS OF TOLL IN USE ON THE PUBLIC IMPROVEMENTS OF THE UNITED STATES, BY CHARLES ELLET, JR., CIVIL ENGINEER.

SECTION 4.—*On the most judicious charge on articles of heavy burden and small value.*

12. I conceive that it is essential to the fulfilment of the condition, that the tax levied on the trade of the line shall be reconcilable with principles of equity, that the charge at each point shall be proportional to the ability of the article to sustain. And, it fortunately happens, that when the charges are regulated in the mode that will produce the maximum revenue, this condition will be fully satisfied.

We are to understand by the ability of a commodity to sustain a charge for carriage, the difference between the cost of production and the market value of the object. If the article be worth $10 in market, and it cost $6 to produce and prepare it for market, it will sustain any charge for transportation, including both freight and toll, not exceeding $4. But its ability to sustain a charge *for toll only*, depends on the position in which it reaches the line of the improvement. For, after deducting the cost of production from the market value, the residue may go to bear the whole cost of carriage; but we must still deduct from this residue the charge for freight, to obtain the sum which it will bear to be charged for toll.

If, for example, the above article reach the line at one hundred miles from the mart, and the freight be one cent per ton per mile, the charge for freight will be $1, and this residue will be $3. If it reach the line at two hundred miles, the charge for freight will be $2, and this residue will be $2. If it come on the work at three hundred miles, the charge will be $3, and the residue will be $1; and if it reaches it at four hundred miles, the freight will be $4, and the residue will be nothing. I say, therefore, that to make the tax for toll proportional to the ability of the commodity, the charge levied by the State for its passage along

100 miles should be proportional to $3,
200 miles should be proportional to $2,
300 miles should be proportional to $1,

and along four hundred miles it should be allowed to pass free. From which it appears, that *the greater the distance the commodity is carried,*

the less should be the toll levied upon it. In short, I propose that the tax should be proportional to the ability of the trade to sustain the charge; and by such a tariff, to supersede those now in use—by which the tax is *increased* in proportion as the ability of the trade to bear the tax is *diminished.*

13. Now, it may be demonstrated, that when the toll is assessed on this principle, both the tonnage and the revenue will be greater than if the most profitable uniform charge per mile that it is possible to levy were adopted.

But the method of determining this most productive charge, cannot be conveniently pointed out, with a demonstration of its correctness, in a mere popular discussion. I have, however, elsewhere considered the subject in some detail, and have shown that the toll on this division of the trade which will yield the greatest possible revenue, is about *three-eighths* of the charge which would exclude the article from market; or three-eighths the limit of the tax which it would bear.

In the above example, therefore, the charge at

100 miles, should be three-eighths of	$3, or	$1 12½
200 miles, should be three-eighths of	$2, or	75
300 miles, should be three-eighths of	$1, or	37½
400 miles,	0	00

The difference between these sums and those above given constitutes the profits of the proprietors.

It cannot be objected to this scale of charges, that it deprives the citizen on the line, near the mart, of any of the advantages of his position. The work, on the contrary, furnishes him with the means of transporting the products of his estate to a market for one-fourth or one-fifth the sum he was compelled to expend before its construction. This is a positive advantage for which he is indebted to the commonwealth; and he has no right tocomplain, if the same commonwealth extend the benefits of the enterprse to more distant citizens. The avowed object of the improvement is to bring to market productions which could not otherwise reach it, and, generally, to reduce the tax on transportation. And if the objection, that the mode of charging here recommended may seem to disturb the relative advantages of position of the near and distant denizen, be a valid one, it is *a fortiori* a conclusive argument against *all* improvement. A consequence of the construction of any canal or railroad, is to increase the value of estates to which it affords new facilities, and of course disturb the relation between the advantages possessed by such property and other estates in the commonwealth, on which it has no effect.

But such an objection, even if a legitimate one, cannot be applied to the scale here advised. It is not proposed to tax the distant man less for the transportation of his effects than the nearer one; on the contrary, he is charged more.* The method merely proposes to make that portion of the tax which is to be considered as the profit of the State—that portion which is levied for revenue—proportional to the ability of the trade to pay it. And this is justice.

*In the example given in art. 12, as we have seen above, the *toll*

For 100 miles	would be	$1 12½
200 "	"	75
300 "	"	37½
400 "	"	00

But the *whole charge*, or freight and toll together,

For 100 miles	would be	$2 12½
200 "	"	2 75
300 "	"	3 37½
400 "	"	4 00

or, actually *increasing in proportion to the distance*, and at the rate of six and a quarter mills per ton per mile.

14. If, now, we represent by a proper scale, as in *Fig.* 2, the area of the country which, with the data of this example, would furnish the tonnage, in the hypothesis of an uniform charge of one cent for freight and one cent for toll, we shall have, as before stated, a triangular figure NPN, with a base, NN, of eighty miles, and height, MP, of two hundred miles.

But if the charges were adjusted with a view to the obtaining of the maximum revenue, the triangle would have a base, *nn*, of fifty miles, and a height, MR, of four hundred miles. In the one case the area of the country would be represented by the triangle NPN, and in the other by the triangle *n*R*n*.

15. But, instead of aiming to obtain the maximum revenue on all the trade which would reach the improvement from R to M, we may, by the system which it is intended to recommend, adopt in both instances an uniform charge for toll, as one cent per ton per mile, from M to M'—the point which corresponds with the intersection *n'* of the sides of the superior and inferior triangles—and confine the arrangement made with a view to the maximum revenue, to that portion of the country situated between M' and R.

The consequence of this arrangement would be to obtain the same tonnage and revenue from the country traversed by the portion MM' of the line, in both cases, since the tariff would in that distance be common; and at the same time to increase the area of the country trading on the improvement, a quantity equal to whatever would be due to this additional trade and the charge upon it, determined in accordance with the principles here laid down.

16. It will be perceived that the increase of tonnage and revenue which, in the preceding article, is shown to have place, will be obtained without any increase of toll on any part whatever of the trade. We have only to take the present tariff of New York or Pennsylvania, or any other state or company, and obtain these results *by a reduction of the charges.*

For, at the point P, which is supposed to be two hundred miles from M, we have seen that a toll of one cent per ton per mile would entirely exclude the trade. But if instead of a charge of one cent per ton per mile, at that point, or $2 for the entire toll from P to M, the article were taxed but seventy-five cents per ton, as is stated (in article 13) to be the proper toll under the circumstances, there would remain out of the two $2, which is the limit of the charge for toll it would bear at that position, a balance of $1 25 to pay the expense of its transportation from *p* to P—a distance of twelve and a half miles on each side of the line. So that, by simply reducing the charge resulting from a tariff proportioned to the distance, we shall here obtain, instead of nothing, a revenue due to the tonnage that would be furnished by a district *pp*, twenty-five miles in breadth, at a charge of seventy-five cents per ton.

It is true that a much more important increase of revenue might be experienced by a modification of the uniform charge supposed to be levied from M to M', and a reduction from the new tariff beyond M'. For, even where we adopt the principle of fixing on the determinate toll per ton per mile for a certain distance, we should bear in mind that there is a certain uniform charge which will yield a higher result than any other. But, without any reference to this, or any of the other advantages which would be derived from a thorough and strict regard to the laws of trade in the establishment of the tariff, I have only sought to render clear the fact, that by *simple reductions of the charges on a portion of the trade on all our public works, the revenue and tonnage may be simultaneously increased, and the tax on the public may be rendered more equitable.*

17. The preceding conclusions are applicable only to the trade in heavy

articles of small value. Equally salutary results might however be obtained by modifications of the charges on the other principal division of the commerce of the country—that which is rendered by its value an object for the competition of rival works. But the examination of the subject with reference to the latter division would, from its complication, be much less susceptible of receiving a popular form. This and other views of the subject, which have always to be considered in any attempt to establish a correct tariff, are examined in considerable detail in my "Essay on the Laws of Trade," where the methods to be adopted to obtain the greatest revenue which the work can possibly extract from the commerce of the country is fully exposed. It is not possible to repeat here, in the narrow space which we can now appropriate to the subject, even the most important of the principles to be regarded in the administration of our public works, which I have there attempted to develope. The glance which is here directed to the question is necessarily confined to a very few prominent points.

To establish a tariff of toll for all articles, on sound principles, requires a certain intimacy with the statistics of the line, and a proper acquaintance with the laws by which the tonnage and revenue are governed. This knowledge cannot be obtained intuitively; and a correct tariff cannot be devised, as those on all our improvements are, by the mere conjectures of the parties to whose discretion such subjects are usually referred.

Section V.—*General Laws of Trade.*

18. There are some facts of a general character relating to this subject which are susceptible of a most rigorous demonstration, that may be here profitably repeated. It has already been shown that a great loss of trade and revenue is sustained in the management of public works by the adoption of a uniform rate of assessment. In the examples adduced, this results from over charges, which, under such regulations, invariably have place in some part of the line. It may be shown by a legitimate course of argument, that however we depart from the charge which will yield the greatest revenue there will be an increase or diminution of tonnage, and, of course, always a decrease of revenue. If the departure be an overcharge, *the tonnage will be reduced a quantity directly proportional to the value of the overcharge, and the revenue proportional to the square of that departure.*

Nothing can prove more conclusively the danger of submitting so important a subject as the preparation of a tariff, to the uncertain guide of conjecture. For, if we err ten mills in the charge which we establish for any article, the loss will be one hundred times greater than if we err but one mill.

19. It is usual to assume that the charge for toll should be proportional to the distance the article is carried—that it should be greater for a great distance than a short one. But we have already seen that, on the contrary in most cases, *the greater the distance the article is carried the less should be the aggregate toll upon it.* (*Art.* 13.)

20. It is common to suppose either that the tariff of toll is independent of the cost of freight, or that the higher the expenses of carriage the greater should be the charge for toll. But, on the contrary, the fact is susceptible of general and easy proof, that *the higher the charge for freight on the line, the lower must be the toll;* and also that *any increase of the cost of freight will at the same time diminish the toll or profit on the article, and increase the whole tax for its transportation.*

21. The charge for toll is also assumed, in the ordinary establishment of tariffs, to be independent of the mode by which the trade approaches the line; and, for many articles, this is true; but, for others, it is an ascertained

fact, susceptbile of easy demonstration, *that if they are brought to the work by a common turnpike a higher toll should be charged for their passage on the improvement than if the same articles reach the work by a railroad, and, a fortiori, than if brought by a canal.*

22. Where the object is to obtain the greatest possible revenue, it is a general law, susceptible of satisfactory proof, that *the charge for toll should not exceed half that charge which would exclude the trade from the line.* It may be shown, however, that, although a higher charge than this can never be advantageously adopted, it may frequently be reduced to *three-eights* of the sum which would cause the exclusion of the trade, with a very beneficial effect on the tonnage, and without leading to any sacrifice on the score of revenne.

23. Another fact, which may be derived immediately from the preceding is, that *where the most judicious charge is levied, the tonnage of the line will be one-half of the tonnage which would be obtained if no toll at all were exacted.*

24. The charge for toll has already been shown to depend in part on the price of freight; and it is an established law that if the cost of freight be increased or diminished by any modifications of the work, or the system of transportation adopted on it, *the toll must be increased just half as much as the freight is diminished, or diminished just half as much as the freight is increased.* And it is further susceptible of demonstration, that the increase of revenue which will follow a general reduction of the charge for freight *will at least be equal to the arithmetical mean between the values of the tonnage before and after the reduction, multiplied by the amount that the freight is reduced.* In other words, if the trade of the line be one hundred thousand tons, and the freight be from any cause reduced $1 per ton, and the tonnage thereby increased ten thousand tons, the revenue of the work will be increased more than $105,000; and this result will have place simultaneously with a reduction of the whole tax on the trade to the amount of $50,000, and the corresponding augmentation of the tonnage.

25. The fact is not usually recognised, that the toll, and tonnage, and revenue, are all more or less dependent on the length of the line of the improvement. It may, nevertheless, be easily proved by a general demonstration, that *the tonnage, the charge which may be levied per ton per mile, and consequently the revenue will all receive an increase by a reduction of the length of the line of transportation.* So that if the toll be judiciously established on any given line, and any material change of location afterward be made, by which the distance, or cost of freight is diminished, there must be a certain increase of the charge for toll, from which an augmentation of revenue will necessarily result. The value of *this increase of revenue is equal to the whole annual tonnage of the line, multiplied by the actual cost of freight through the distance saved*—and, considering only the value of the trade, it is therefore worth, to reduce the length of the line, the capital of which the interest is equal to that sum.

26. In the arrangement of the charges in a tarriff, there is no subject of greater importance, for some articles, than the positive, and for others, than the relative, value of the mart. From the positive value of the article, is determined the tax which one division of the trade can sustain; and from the relative value is in part deduced the proper toll on all commodities for which other works are competitors.

A permanent change of the relative standing of the mart, ought, therefore, to superinduce a modification of the toll. And it may be easily shown that if the relative value of the market—by which is intended its value compared with that of the rival mart—be increased any given sum, we shall find

the corresponding increase of toll per mile proper to be made, *by dividing that increase by twice the length of the improvement in miles.* If, for instance, the value of Philadelphia as a mart for tobacco, compared with the value of New Orleans in reference to the same article, be, from any cause, increased $4 per hogshead, and the distance from Philadelphia to Pittsburg be four hundred miles, then, I say, the toll on tobacco on the whole central line of the Pennsylvania improvement, should be increased a half-cent per ton per mile.

It is also easy to demonstrate that, at the same time, *the revenue will be augmented by any increase of the relative value of the market, an amount obtained by multiplying the original tonnage added to half the increase of tonnage consequent on an improvement of the market, by the increased value of the tonnage at the market.*

It is shown, in fact, that whatever circumstance occurs to increase the value of the property sent along an improvement, to the holder of the property, will cause a certain increase of tonnage, of which the measure can be obtained, and a simultaneous augmentation of revenue equal to the whole increase of its value; and that *whatever unnecessary tax is levied on the trade, is at least so much deducted from the revenue of the improvement.* If, for instance, the engineer in making the location permit his line to be one mile longer than is essential, he will thereby cause to the State or company an annual tax, or equivalent loss of dividend, equal to the whole annual expense of transporting the whole trade of the country through that mile. He incurs, at the same time, the responsibility of reducing the tonnage of the work, and of injuring, to a certain extent, both the country that supplies the trade, and the emporium which receives it.

If he embarrass the line by an unnecessary grade, or any other impediment which involves a similar increase of the charge for freight, he is responsible for the same result; and, before adopting such a measure, is bound to compare the value of the difficulties to be avoided, with that of these inevitable consequences to the future trade.

28. It is an error, and a very frequent one, to suppose that the toll is in any manner dependent on the cost of the work; or ought, under any circumstances, to be directly proportional to the value of the article. It is, however, not uncommon to assume, that it ought to bear some relation to the cost of construction; and there are tariffs of toll in the data for the calculation of which the value of the commodity is in principal, if not the only element. It is not a little singular that, after encountering an expense of hundreds of millions for our public works, the tariffs by which they are to be sustained should be entirely ruled by considerations which, however plausible in a superficial view, have no legitimate relation to the question.

For one division of the trade, it is not the positive value of the commodity, but the difference between the market value and the cost of production; and for the other, the difference between the value of the article at the mart of the improvement and at that of its rival, by which the toll is influenced. And this influence is only partial. The value of the article, taken in any sense, is only a part of the data by which the true charge must be determined.

29. It is by no means the intention here to attempt a general analysis of this most important subject. My object, as already announced, has been to show that, under certain circumstances, a marked increase of trade and revenue may be obtained on all our public works, by simply reducing the charges; and that such modifications of the tax levied on the community is rendered imperative by the first principles of equity. If I have succeeded in making this truth perfectly apparent, the design of these pages will be fully accomplished.

I scarce hope to have satisfied the reader in a discussion so brief and popular, that to enable a company to take the full advantage of its position, and obtain the highest degree of success of which their enterprise is susceptible, demands a careful and close investigation of the laws of trade in reference to every branch of the subject. To appreciate the importance of this course, requires that the mind should have investigated such questions sufficiently to estimate the consequences of its neglect. To know the value of establishing the most correct tariff, we need to know what we are likely to lose by the adoption of a conjectural or empirical one.

This subject, though usually taken under other auspices, is peculiarly a professional study. An intimate acquaintance with the principles which govern the trade of an improvement, is a department of knowledge which is essential to the engineer in the location of his line, and the establishment of many of the plans of his work. His first duties, when properly discharged, compel him to become the most intimately acquainted with the productions and statistics of the country, and the information acquired in the accomplishment of these labors, ought to be turned to account in directing the future administration of the line.

The preparation of the tariff is, or ought to be, the peculiar province of the engineer. For, though there may be many considerations of policy, which should have a certain weight with those whose final action is requisite to carry his recommendation into effect—and which may frequently render it advisable to modify the charges which an *a priori* investigation may indicate to be proper, where the questions of trade and revenue only are under consideration,—still, it is not less important that the tariff should first be correct in itself, that some estimate may be made of the effect that will be felt when such political modifications come to be admitted. And, withal, it is difficult to conceive what motives of policy should induce any material departure from those limits which the administration of justice, the promotion of trade, and the augmentation of the revenue simultaneously recommend.

LE COUNT ON RAILWAYS.

"Uniformity in the width of track" finds as little favor on the other, as on this side of the water.

When the contracts along the line are fairly at work, one of the first knotty points which the directors will have to decide on, is, the width of the rails, their shape, the length of their bearing, and the form of their chair. The width between the rails has only lately become a subject of dispute, nearly all the railways prior to the Great Western, having been laid down 4 feet 8½ inches apart. Mr. Brunel has extended it to seven feet, the Irish railway commission recommend six feet two inches, several of the Scottish railways are laid down at five feet six inches, in fact, the variations run from four and a half to seven feet.

The question of the stability of the carriages on the railway may be left out of consideration in looking at this matter, because the machinery will always require sufficient space between the wheels to insure this. Now, as 4 feet 8½ inches are found to be enough for the good performance of an engine, which with 5½ feet wheel, will go on a level upwards of 69 miles an hour, as with 5 feet wheels, Marshal Slout, on his visit to Liverpool just after the Queen's coronation, was taken over 10¾ miles of favorable ground on the Junction Railway within 10 minutes, & as an engine has gone 60 miles Grand an nour on the London and Birmingham Railway, up an inclined plane, is it wise or prudent to make any change at all, and will any additional

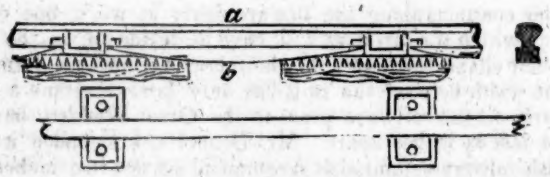
speed, which may be gained by increasing the width of the rails and the diameter of the wheels compensate for the greater expense of the outlay which will constantly be required to keep the road in order on account of the increased weight? This will receive light from the experiments on the Great Western, but will not be fully decided until it be tried on the Irish or some other railways, as Mr. Brunel's rails are altogether different from most others in use. The plan recommended by the Irish railway commissioners, of putting the rails farther apart but not widening the carriages, merely making the wheels run outside the bodies, is a good one in some respects; but it would add to the expense of the works considerably, and the result would be exceedingly questionable.

It must not be forgotten, that, where a different width from that in common use is adopted, the railway on which it is used becomes isolated. None but its own carriages can travel on it, and they can travel on no other line. This alone will, in most cases, be a serious objection. For our own parts we should say, let well alone; wait for more experience; we are yet infants among railways, and we ought not to innovate on that which has proved to do well, until we become giants. The majority of opinions, however, are beginning to lean towards some increase in the width, although there is every diversity in the quantity which practical men think necessary. Certainly the machinery under the boiler is compressed into its minimum space, and more room for it would be a great advantage, if it does not induce an incommensurate loss in other ways.

With respect to the form of the rail, it can be proved that a fish belly has greater strength, weight for weight, than any other. A 60 lb. fish belly at three feet bearings, rolled with a lower web, would be the best form of all; and this has been effected, as the original Liverpool and Manchester rails had partially this shape. The question, however, must be looked at in conjunction with the length between the supports. We have given below those forms most approved of in practice, and have added that in use on the Great Western Railway, which is however light, and does not stand well, three feet having been the original distance of the bearings.

Fig. 1 is the old Liverpool and Manchester rail, laid down at three feet bearings; weight thirty-three lbs. yer yard, with square joints. This rail

Fig. 1.

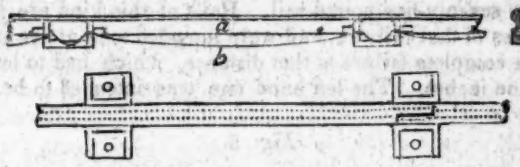


was rolled with a lateral swell at the bottom, which on one side was continued the whole length, but on the other did not quite reach the chair.—One side of the chair was cast with a cavity, into which the lateral swell fitted, and the opposite side had a nearly similar opening, in which was driven an iron key, shaped like a wedge, which, entering in a longitudinal direction, not only forced the swell into the cavity which was formed to receive it, but by this means, at the same time, kept the rail down in the chair.

Fig. 2. Losh's patent rail, in which he sought to gain a still more powerful mode of keeping the rail down in the chair, by having his key tapered vertically as well as longitudinally, so as to act as a wedge downwards, as well as in the direction of its length; whilst, at the same time, the neces-

sary expansion and contraction is allowed to take place. A key on each side has also been used with this form of rail, still, however, the keys were always found to work loose. Losh had also a projection rolled on the bot-

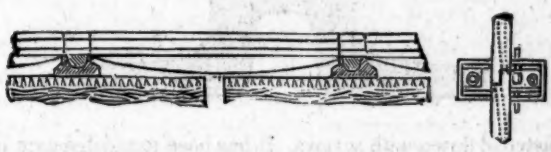
Fig. 2.



tom of his rail; at the part which lies in the chair, where a corresponding cavity was cut to receive it, so that the effect of expansion or contraction would have a tendency to raise the rail in the chair, and thus wedge it tighter. The upper part of the notch for receiving the key in the chair was also formed with a slight curve, to allow of a small motion in the block, and the rails were made with a half-lap joint, formed not by cutting the middle rib of the rail, but by setting it back, so as to preserve its whole strength.—They were laid down at three feet bearings, and weighed forty-four lbs. per yard, but of course were not restricted to that, or to any other weight.

Fig. 3. The London and Birmingham fifty lbs. fish bellied rail. This was laid down at three feet bearings, and the half-lap joint formed by setting back the middle rib instead of cutting it, in the same way as Losh's rail. It was keyed down by a pin going through the side of the chair in a direction sloping downwards. The end of this pin went into a notch in the side of the rail, at its lower parts; the pin was forced tightly in by an iron key acting through the chair, and also through a hole in the pin, by

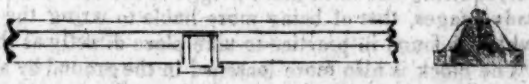
Fig. 3.



which it was driven both in and downwards; and the end of the key being split, was then opened, to prevent its being shaken loose. Mr. Stephenson has a patent for this chair. The rails did not rest on the bottom of the chair but on a loose piece of iron, the lower part of which was the segment of a circle, and the upper part flat, and of the same width as the middle rib of the rail; and this worked in a circular cavity in the chair, so as to allow a motion when deflection took place in the rail. These rails had no bottom webs.

Fig. 4 is the St. Helen's and Runcorn rail, with a bottom web, having a semicircular base. These rails are forty-two lbs. per yard, and were laid down at three feet bearings. A wedge on both sides is used, which acts

Fig. 4.



downwards as well as sideways, from the opening in the chair to receive it being narrower at the top than at the bottom.

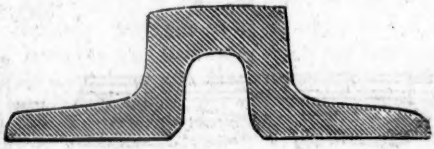
Fig. 5 shows the parallel rails laid down on the Grand Junction, and London and Birmingham railways. The left hand one is sixty-four lbs. per yard on the Grand Junction. The right hand one is the London and Birmingham seventy-five pound rail. Rails of this kind are laid on seventy-five miles of that railway, and were intended to be at five feet bearings, but proved a complete failure at that distance, which had to be reduced to three feet nine inches. The left hand one was intended to be at four feet

Fig. 5.

bearings. These rails were both laid down contrary to the opinion of the engineer, Mr. Stephenson, and have entailed a vast expense on that company. They have wooden wedges.

Fig. 6 is the Great Western rail, laid on longitudinal timbers, and forty four lbs. per yard. Felt is laid between the rail and the timber, and the

Fig. 6.



former is fastened down with screws. It has been found deficient in strength for the heavy engines used upon that railway.

Fig. 7 has been frequently adopted on railways formed with longitudinal bearings. It is spiked down to the timbers, and requires no chair. The weights have varied from thirty-five to sixty lbs. per yard. Sometimes the spikes have not gone through holes in the rail as in the figure, but have been driven in just outside each edge of the rail; in which case they are made with large heads, which come down and clip the rail firmly to the timbers.

Fig. 7.

The London and Birmingham railway companies, after a long discussion, decided to try four and five feet with a parallel form instead of a fish-belly, which, requiring one-third more height in the chair, had, in addition to other disadvantages, that of being more liable to wring the chair from the block, which is found in practice to take place directly as the height of the chair. The block is also more loosened in the ground by a high chair and the continual repairs arrising from this loosening, amount to one-half

the wages expended in repairing the way in general; hence every means of diminishing such a heavy item, which can possibly be devised, should be put in practice. As usual, where all was theory, there were considerable diversities of opinion. Those who wish to enter more at large on this subject, may consult Professor Barlow in favor of lengthening the bearings, and Lieut. Lecount against it. As the matter has had a fair trial, it is only necessary here to state the results.

On the Primrose Hill contract, which was laid with four feet bearings, it was found much more troublesome to keep the permanent way in order, than with bearings of three feet. With the four feet bearings, it was found, that, in a very short time, the rails were put out of gauge, the width continually increasing, until it became absolutely necessary to re-adjust the whole. This was observed in a very marked manner with a part of the line near Kilburn, which had been recently laid down.

On the Harrow contract, from the crossing of the Harrow road to No. 12 cutting, the permanent road was used for conveying away the material from a side cutting. The traffic was of course considerable, but not by any means such as to account for the absolute difficulty which the contractors had in keeping the railway in guage. They were obliged to put sleepers at the joints in addition to the regular number of blocks, which of course kept the rails in guage at those points; but notwithstanding this, the intermediate blocks moved outwards. When the engineer's attention was first called to this position of the permanent way, he was inclined to think that something might be attributed to the blocks being placed anglewise; but after giving this part of the subject his careful consideration, he felt satisfied that the position of the blocks was at least as firm as the square position; and he felt confirmed in this opinion, by the fact, that, in another portion of the line near Kensal Green, where the road was laid in the ordinary manner with blocks three feet apart, and placed anglewise, and where locomotive engines had been constantly running for eighteen months, there was not found any greater tendency to a motion outwards, than when they were laid square to the direction of the rail, in the old manner. If, therefore, the diagonal position of the blocks had been defective, this was the place to try it; for the quantity of material conveyed over this part of the permanent road in wagons without springs, and with heavy locomotive engines, was very great indeed, and under circumstances well calculated to detect any marked difference in the construction.

On the Berkhempstead contract, where five feet bearings were in use, and were a locomotive engine was at work, the contractors made heavy complaints of the greater difficulty they had experienced in keeping the rails in guage than there was with the shorter bearings. In fact, in the eighteen months prior to June 1837, the three feet rails in some parts of the line, had more work than they now have, where the line is open; yet they stood it well, while the five feet have been so put out of gauge by one day's work, that the wagons had to be stopped till one and two additional sleepers for each five feet could be laid down, and even then they were but indifferent; and similar complaints having come in from other quarters, together with the fact that the five feet bearings on the Liverpool and Manchester railway were found to cost double the sum for keeping the way in repair that was required with three feet nine inches bearings, the whole question had to be opened again, and the directors resolved to shorten the bearings from five feet to three feet nine inches.

This lateral deflection is of most serious importance, when we recollect that the rails being out of guage will throw the trains off the line.—The lateral blows which an engine may give are such, that several chairs

in succession have been broken or knocked off the blocks and sleepers; and the absolute weight passing over any one rail may be fairly taken as three times the nominal weight, for the effect from lurching has been experimentally found with engines having three tons' weight on each of the driving wheels to increase that weight to seven tons; besides which, we know that four wheeled engines, for instance, will, in practice, be frequently running on three wheels, no railroad being a perfect plane; and when these three points are in the act of shifting, the engine during that time is only supported on two wheels.

The flexure produced by this weight perpendicularly has also this bad effect, that the engine and train are constantly ascending an inclined plane in practice, although the railway is considered as level, and of course where the railway has an inclination, that inclination will be proportionally increased. This was first pointed out by Professor Barlow, and is an important fact; for on the short planes between each block or sleeper caused by the deflection of the rail, the gain in descent is so insignificant, that it may be entirely neglected; consequently the engines and carriages are constantly going up an inclined plane between each support of the rails equivalent to the central deflection divided by twice the distance between the supports. This is, from calculation, ascertained to be as follows, viz.:—

Bearing distance.		Deflection.	Equivalent planes.	Increased Power required per ton.
Ft.	In.	Inches.		
3	0	·024	1 in 3000	·75 lb.
3	9	·037	1 in 2432	·92 lb.
4	0	·041	1 in 2341	·95 lb.
5	0	·064	1 in 1875	1·20 lb.
6	0	·082	1 in 1756	1·30 lb.

Although the deflection of rails will generally be different from the above, and the increase of power required to surmount the consequent planes will also require considerable modification to suit the action of locomotive engines, which depend upon so many other circumstances besides the action of gravity; yet the fact remains the same, namely, that with deflection there is a consequent loss, and the subject deserves much more consideration than it has received, especially as we know that fish-bellied rails do not fail in the middle, but about eight inches from the supports. A rail ought not to act as a spring; but as this to a certain extent must be the case, it should be made to do so as little as possible. A spring should only be used to get over an obstacle where one must be met, but if the rail acts as a spring it creates an obstacle where none existed before. We must also remember that when deflection becomes permanent, fracture begins, as we break a thing we are not strong enough to pull asunder, by bending it backwards and forwards. In fact, the experiments on deflection have hitherto been such that they have merely served to unsettle all opinion, and to place one set of deductions in opposition to another. The mode of estimating this element by two wheels on an axle, loaded at their peripheries, and oscillated on the rails, is one which well deserves attention. In all cases, the firmer the rail is fixed to the chair, as respects rising in it, the less will be the deflection. Of course it must always have a motion in the direction of its length to allow for expansion and contraction, the force of which will vary in good or tolerable iron from nine to six tons per square inch of section. The expansion of a fifteen-feet rail may be taken at ·00126 inches for each degree of Fahrenheit, and as it will not be safe to take less than

90° for the range of our climate, this gives ·1134 inches for the total, or ·0567 at each end of such a rail.

In order to understand the action which takes place in the case of a deflected rail when a heavy weight passes over it, we must know the effect of gravity at the velocities used on railways. For this purpose, if we take three, four and five feet beraings as those which seem at present likely to be the limits, the following table will give us the time occupied in going over half the rail in each case; and from this we shall be able to ascertain the effect of gravity during that time.

Velocity in miles per hour.	Velocity in yards per minute.	Velocity in inches per second.	Parts of a second in which 18 inches are passed over.	Parts of a second in which 24 inches are passed over.	Parts of a second in which 30 inches are passed over.
10	293·33	176	1-9·8	1-7·33	1-5·86
20	586·66	352	1-19·6	1-14·7	1-11·73
30	879·99	528	1-29·3	1-22	1-17·6
40	1173·32	704	1-39·1	1-29·3	1-23·47
50	1466·65	880	1-48·9	1-36·7	1-29·3
60	1759·98	1056	1-58·7	1-44	1-35·2
70	2053·31	1232	1-68·4	1-51·3	1-41·1
80	2346·64	1408	1-78·2	1-58·7	1-46·9
90	2639·97	1584	1-88	1-66	1-52·8
100	2933·30	1760	1-97·8	1-73·3	1-58·7

Or putting a for the velocity in miles per hour, v for the velocity in yards per minute, and v' for the velocity in yards per second, we have

$$v = \frac{1760 \cdot a}{60} = 29{\cdot}333a \qquad v' = \frac{1760 \cdot a}{3600} = 4{\cdot}888a.$$

And in the table, taking either of the three right hand columns, accordtng to the length of bearing, for instance the eighteen-inch column for a three feet rail, we have the number of inches through which the engine or any other body would fall by the action of gravity in free space, in the time which it takes to pass over 18 inches at the given velocity, by the formula $s = t^2 \cdot 193$, where t is the time in seconds, and s the space in inches. Thus at 20 miles an hour, with a three feet rail, where 18 inches are passed over in $\frac{1}{19{\cdot}6}$ of a second, the engine would fall during that time

$$\left(\frac{1}{19{\cdot}6}\right)^2 \cdot 193 = \frac{1}{384{\cdot}16} \cdot 193 = \frac{193}{384{\cdot}16} = {\cdot}5,$$ or half an inch.

Again at 30 miles an hour, with a three feet rail, 18 inches of which are passed over in $\frac{1}{29{\cdot}3}$ of a second, the engine during that time would fall

$$\left(\frac{1}{29{\cdot}3}\right)^2 \cdot 193 = \frac{1}{858{\cdot}49} \cdot 193 = \frac{193}{858{\cdot}49} = {\cdot}225,$$ or not quite a quarter of an inch.

And denoting by t and s the time and space as above, we have conversely, knowing the space an engine would have to fall, for instance, through a bad joint, the distance the engine would pass over without touching the lower rail, by the formula

$$t = \sqrt{\frac{s}{193}}.$$

Thus when $s = {\cdot}225$, we have

$$t = \sqrt{\frac{{\cdot}225}{193}} = \sqrt{{\cdot}001166} = {\cdot}0341 = \frac{1}{29{\cdot}3}$$

of a second, in which, at 30 miles an hour, we find by the table the engine

would pass over 18 inches of the lower rail without touching it, describing in its fall a parabola modified by the effect of the springs on the engine.

This has been put to the test of experience by bending a rail nearly half an inch, and then painting it. An engine and train of carriages were then run over it, none of the wheels of which touched the paint for 22 inches. This affects a railway in three ways. First, when the engine has to fall, through a bad joint, the rail which it leaves being higher than the rail it is coming upon, the increased momentum from the fall will here occasion a larger deflection than ordinary, and a consequent inclined plane against the engine, from the time it comes on the rail till it passes the next chair. Secondly, when a rail is permanently bent, where the resistance on the second or rising part of the rail will be less than in the first case. And thirdly, when the rail is simply deflected by the weight of the engine, and restores itself to its original level when that weight has passed; here the effect will be least of all, the rail taking the form of a receding wave before the wheel and a following wave after it.

In the second case, where the rail is permanently bent, the formula for the space the engine would fall will be

$$s=\frac{H}{L}\cdot 193\cdot t^2,$$

where H is the height of the plane, and L its length, s and t being as before. For instance, if the bend is ·1 of an inch in a 3 foot rail, we have

$$s=\frac{1}{180}\cdot 193\frac{1}{858\cdot 49}=\cdot 00125 \text{ of an inch, at 30 miles an hour,}$$

and $s=\frac{1}{180}193\cdot\frac{1}{384\cdot 16}=\cdot 00278$ of an inch at 20 miles an hour, or $\frac{1}{360}$ of an inch at 20, and $\frac{1}{800}$ of an inch, at 30 miles an hour, would be descended by the engine by the effect of gravity, in the same time that steam and gravity together take it along 18 inches of the rail.

Let us next suppose we have steam enough to carry the engine along at a velocity so great, that gravity will not bring it down the ·1 of an inch perpendicular, whilst steam carries it along the 18 inches horizontal, we shall find this velocity to be at and above 44 miles an hour, for it takes $\frac{1}{43}$ of a second for a body to fall one-tenth of an inch by the effect of gravity, and $\frac{1}{43}''$: 18 in. =3600″ : 44 miles; hence at 44 miles an hour, and at all velocities above it, the engine, after arriving on the rail, bent one-tenth of an inch in the middle, and forming two planes, will no longer touch the rail till after it has passed the middle of it, and velocities of 60 miles an hour have been attained.

(To be continued.)

Erie Canal Enlargement.—A series of articles on this subject, have been lately published in the Railroad Journal, under the signature of Fulton, which appear to us to be both timely and appropriate. Other numbers are yet to follow. The writer calculates the whole cost of the enlargement, including damage and loss of interest, at $40,000,000!! He shows from the annual Reports of the Comptroller, that in consequence of the gradual destruction of the forests in the neighborhood of the canals, the down tonnage has fallen off within the last five years to the extent of 140,000 tons, will not, for a long time to come, be made up by the increase of agricultural products; that even double locks are not *now* wanted; and that any enlargement beyond adding 12 or 18 inches to the banks, will be money thrown away. He complains of the impolicy and injustice of making private enterprise, as developed in railways along the line of the canal, *tributary* to the State, as a means of defraying the interest on the enlargement. He re-

buts the doctrine heretofore maintained by some, that the effect of the enlargement will be to reduce transportation 50 per cent. Persons interested in the subject, as every citizen of the State is, either directly or indirectly, will do well to refer to the articles themselves. We perceive, as yet, no decisive movement in the Legislature, having for its object to arrest the enormous expenditure which is being entailed upon us. The subject will be thoroughly scanned by posterity—of that be assured. Forty million dollars, or twenty millions, if such a debt is incurred for the proposed enlargement, will be an incubus upon our credit and resources, which it will not be easy to shake off.—*Jour. of Commerce.*

LOCOMOTIVE ENGINES.—The statement of the performance of the Locomotive Engine "Minerva," on the Philadelphia and Reading railroad which we take from the United States Gazette, will be found interesting and useful on account of the business like manner in which it is prepared.

More of the Philadelphia Engines.—We have great pleasure in presenting our readers with the subjoined statement of the performance of the "Minerva" Locomotive Engine, built by William Norris, Philadelphia, on the Philadelphia and Reading Railroad, with a train of 85 loaded cars, January 15, 1840.

	No. cars.	Gross load. Tons.	Running time. h.	m.	Water used. Gallons.	Wood used. Cords.	Distance. Miles.	Fall. Feet.	Average fall per mile. Feet.	Longest level. Miles.	Total level. Miles.	REMARKS.
Between Reading & Pottstown,	54	227	1	1	322	0.4	17.5	113.8	6.5	4.3	5.1	Wood seasoned, dry.
Pottstown & Phœnixville	62	261	0	56	329	0.65	13.0	40.2	3.1	2.5	7.4	do. do. do.
Phœnixville & inc. plane,	85	350	2	47	886	1.14	24.0	59.5	2.5	9.1	15.3	Wood green
Total,			4	44	1537	2.19	54 5	213.5	3.92		27.8	

Two quarts of oil only were used by the Engine and Tender in the trip, including oiling before starting. Nett weight of freight 216·3 tons gross weight, 350 tons or 784,000 lbs.

In the above statement the tons mentioned are *gross* of 2240 lbs.

Weather clear and cold, rails in good order.

Weight of engine, empty,	23,040 lbs.
With water to second cock,	25,730 "
With water, fuel, and two men,	26,300 "
On four driving wheels,	15,150 "
On driving wheels, with water and fuel,	17,450 "
On driving wheels, with water, fuel and two men, or in running order,	17,900 "

Her tender holds 504 gallons water.

The engine started the train of 85 cars three times on a level; and on one occasion in a curve of 955 feet radius, without any straining or difficulty, and at various times attained a speed of 14 miles per hour through some curves of the above radius on a level.

The quantity of steam generated, when common dry oak wood was used was more than sufficient to supply her cylinders; and from the surplus quantity which escaped from the safety valve, I have no doubt she could

have taken 20 more loaded cars, or 90 tons, had they been ready, and without any injury to her machinery. Signed, G. A. NICOLLS.

Superintendant Transportation Phila. and Reading Railroad.

Reading, Pa. January 18, 1840.

For the American Railroad Journal, and Mechanics' Magazine.

METEOROLOGICAL RECORD FOR THE MONTHS OF NOV. and DEC., 1839.

Kept on Red River, below Alexandria, La., (*Lat.* 31.10 *N.*, *Long.*, 91.59 *W.*)

1839	THERMOMETER.					REMARKS.
Nov	Morn.	Noon.	Night.	Wind.	Weath.	
1	55	70	66	calm	cloudy	light shower forenoon
2	56	69	67	..	clear	light shower at night
3	62	68	66	..	..	cloudy morning clear day
4	66	74	75	s high	..	all day
5	63	69	58	NW high	..	"
6	46	62	51	W	..	
7	40	54	50	NW	..	white frost
8	36	60	50	calm	..	"
9	38	62	52	..	..	"
10	41	72	65	..	..	rain in the night
11	65	71	64	W	..	
12	46	73	67	..	..	foggy morning
13	47	76	67	SW	cloudy	rain in the evening
14	45	76	68	..	..	heavy showers all day
15	51	53	51	NW	..	morning, evening clear
16	44	53	50	NE	clear	
17	45	65	61	calm	..	foggy morning
18	48	69	66	..	..	
19	51	68	66	W	..	
20	52	52	50	N	cloudy	
21	45	46	42	NE	..	rain evening and all night
22	40	42	42	..	..	" steady all day and all night
23	40	41	40	N	..	all day
24	38	44	48	NW	..	morning, clear day
25	30	31	30	N high	..	all day
26	23	36	37	calm	..	" [night
27	36	46	48	NE	..	rain light showers and drisling all day and all
28	48	52	53	calm	..	light drisling rain all day and all night
29	47	47	48	N	..	
30	44	58	52		..	evening clear
	47	59	56	.....	.....	mean temp. of the month 54.
Dec.						
1	44	48	47	calm	clear	foggy morning
2	46	60	54	NW light	..	
3	32	61	52	calm	..	white frost
4	32	56	52	..	..	"
5	36	48	49	..	cloudy	white frost, rain in the evening and night
6	53	54	50	..	..	thunder shower in the morning, drisling rain
7	33	59	52	..	clear	white frost [all day
8	34	46	42	NW high	..	"
9	28	52	56	SW	..	"
10	34	62	60	..	..	"
11	56	58	52	NW	..	"
12	31	50	46	W	..	"
13	32	62	60	SW	cloudy	all day
14	48	56	50	NE high	..	"
15	36	50	46	calm	clear	white frost
16	33	50	40		..	"
17	34	56	44	NE	..	"
18	40	60	56	calm	cloudy	
19	38	48	50	..	..	
20	56	63	56	SE	..	rain all the forenoon, evening calm and clear
21	46	48	48	NW	clear	
22	36	47	50	..	..	
23	40	40	40	NE	cloudy	rain afternoon and all night
24	36	40	38	calm	..	
25	36	50	46	..	clear	white frost
26	44	58	50	..	cloudy	rain all the forenoon, cloudy all day
27	38	50	44	..	clear	white frost
28	42	54	48	W	..	"
29	32	50	48	calm	..	"
30	46	63	63	SW	cloudy	rain and thunder at night
31	40	34	35	NW	clear	
	39	56	48	.....	.....	mean temp. of the month 48.